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A TRANSDUCER TO REDUCE STANDING WAVES

by

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ABSTRACT

An underwater sound transducer having a directivity pattern rotated 10 degrees from the normal to the face of the transducer has been constructed and tested for use in making c-w acoustical measurements in a small tank. Standing waves between the faces of the two instruments involved were thus eliminated or substantially reduced. Other uses may suggest themselves to the reader who is interested in underwater sound measurements on reflecting and absorbing surfaces without resorting to a pulsing technique.

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Charles L. Darner

I. INTRODUCTION

The need for a transducer with a nonreflecting face to eliminate the establishment of a standing wave system between projector and receiver occurs frequently in c-w underwater sound measurements. The construction of such an instrument is, of course, impracticable, but a method of producing equivalent results has been developed at the USRL.

A network of inductors has been applied to a Rochelle salt transducer to rotate the directivity pattern 10 degrees from the normal, making it possible to operate the transducer with its face in a plane not parallel to the face of the second instrument. The reflected sound energy is thus diverted from the normal transmission path by an angle of 20 degrees.

The theory of operation and the mechanical construction are relatively simple. The transducer is instantly returned to normal operation by a shorting switch.

II. CONSTRUCTION OF THE TRANSDUCER

The first model of this type transducer, now being used at this Laboratory, is a modification of an older transducer. The transducer was reconstructed as a square array having five electrically isolated vertical rectangular sections. Each section is composed of 24 Rochelle salt crystals 1/8 by 1/2 by 5/8 inch active in the latter dimension. The five sections are mounted on a glass backing plate in a square mosaic with sides 3 inches in length. A 6-foot length of shielded 5-conductor cable connects one terminal of each section to a junction box. The opposite terminals of the sections are common and connected to the cable shield.

Lagging inductors, connected as shown in Figure 1, were so chosen as to give a 10-degree angular deviation to the directivity pattern in azimuth. The theory of this type of electrical system with recurrent similar sections has been well covered in the literature on artificial and infinite lines[1] and will be omitted in this paper.

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[1]Everitt, W. D., *Communication Engineering* (Second Edition, New York: McGraw-Hill Book Co., 1937)

Pierce, G. W., *Electric Oscillations and Electric Waves* (First Edition, New York: McGraw-Hill Book Co., 1920)

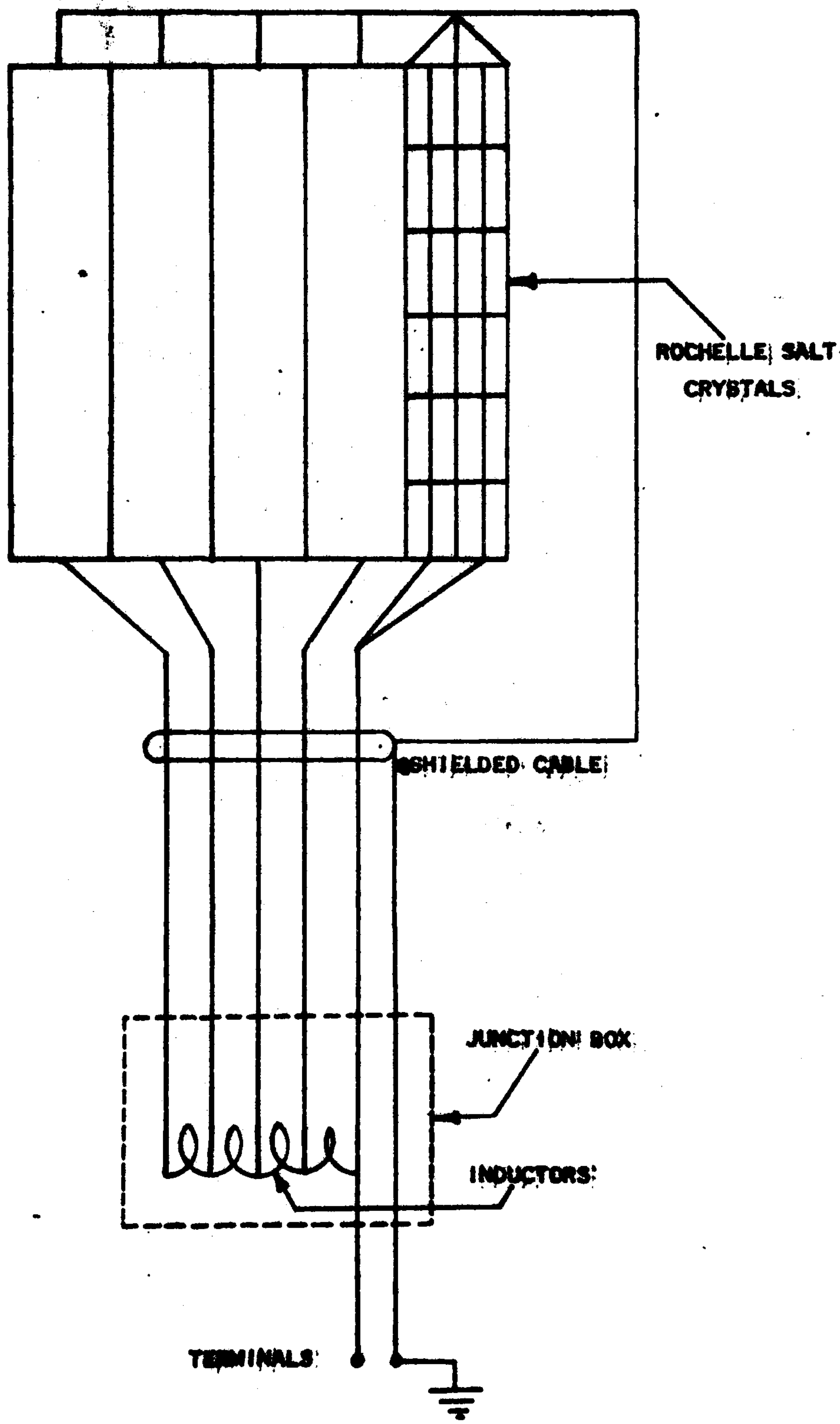


Figure 1. Schema of Transducer and Lag Line

Calculation of the proper value of inductors assumed the Rochelle salt crystals to be perfect capacitors, since their inherent variability with fluctuating temperature would invalidate more accurate calculations almost before they were made. No provision has as yet been made for water temperature control in the small tank presently used for experimental investigations.

III. DESCRIPTION AND RESULTS OF TESTS

Measurements to date have included directivity rns of the transducer, and transmitting response gainst two primary underwater sound standards now in general use at this Laboratory. These measurements were made with lagging inductors in the circuit and then compared with results obtained with the transducer in normal operation (all inductors short circuited).

Figures 2 and 3 show the shift in directivity of the main lobe at frequencies of 70 kc and 140 kc respectively. The increased height of the secondary lobe on the right side of the patterns is attributed to the finite width of the phased rectangular strips. No attempt has been made to overcome this, as it has caused no interference in our acoustical work because of the use of a sound absorbing baffle in the tank.

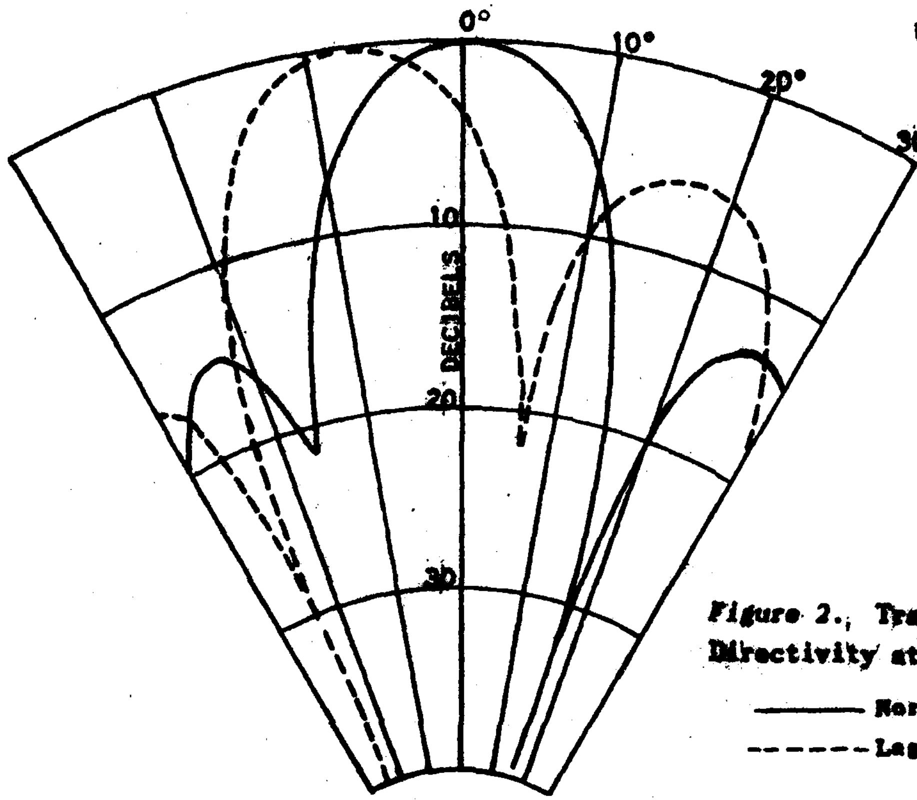


Figure 2. **Transducer Directivity at 70 kc**

——— Normal
- - - - - - Lag Line

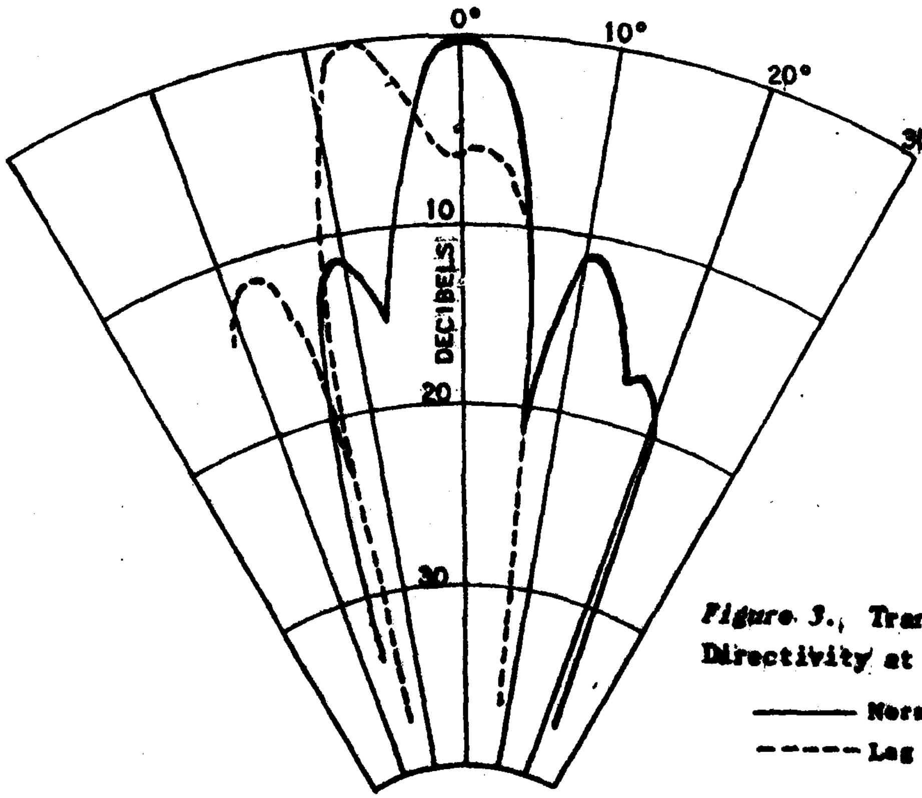
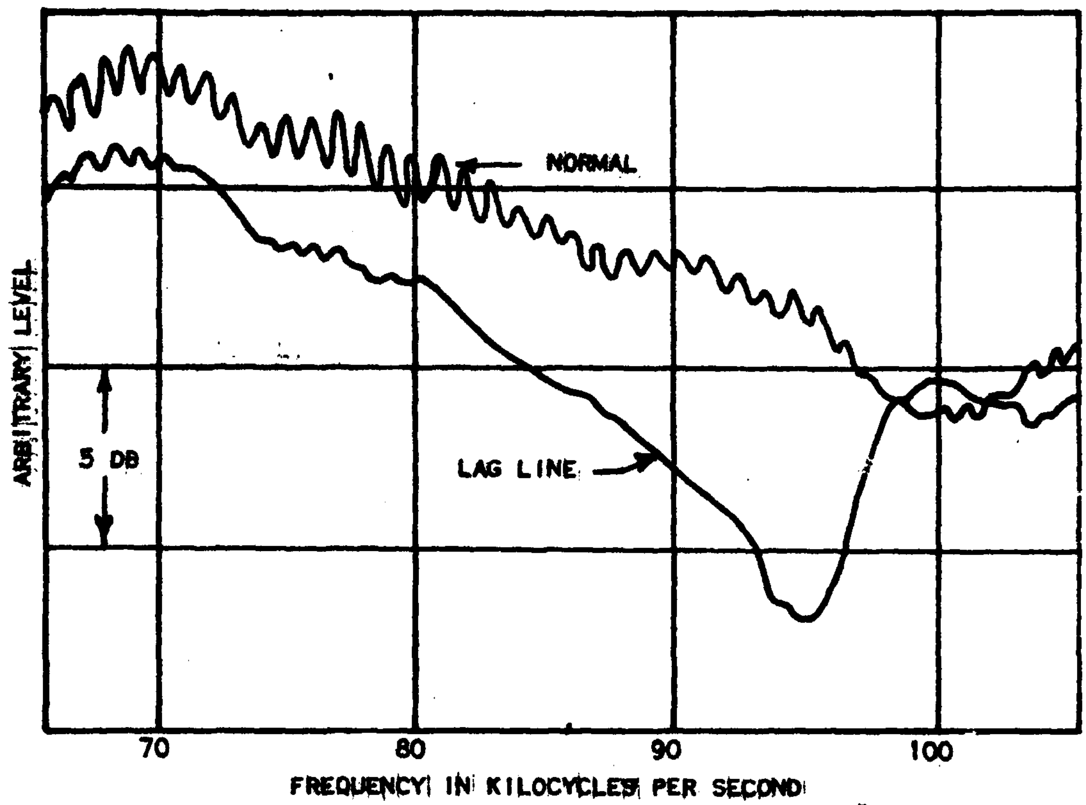


Figure 3. **Transducer Directivity at 140 kc**

——— Normal
- - - - - - Lag Line

These patterns show that the time lag of current from section to section is practically constant over the necessary frequency range (30 kc to 150 kc). All patterns were made at a test distance of 184 cm in a large test tank using the well known pulse technique. Some variation of current time lag exists, of course, because of the capacitance change of the crystals with frequency. An examination of directivity patterns throughout the entire frequency range showed the beam to vary in angular offset by 2 degrees. This has not affected calibration tests of other instruments.

Figure 4 is a reproduction of the recorder chart reading for two bands of frequencies, including the respective frequencies at which the directivity patterns were taken. The transducer was used as a c-w projector, and a standard hydrophone with an overall face diameter of 3 inches was the receiver. The absolute level is not pertinent to this discussion, and has been omitted. The two traces have been separated in level for easy reading. This chart tracing shows that the standing wave system influenced the chart reading by as much as 2.5 db with the projector operating normally. Larger hydrophones have increased this figure to 4 db. The use of an off-axis beam is shown to eliminate almost entirely the building up of a standing wave system.



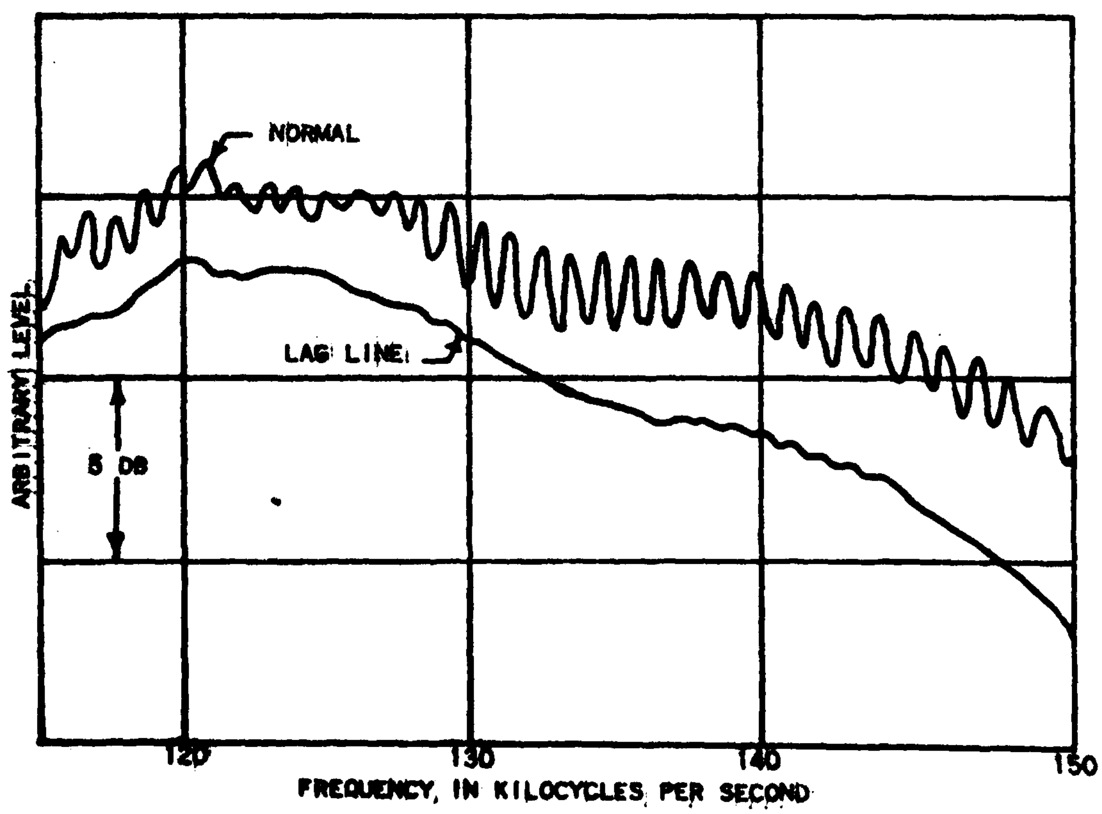


Figure 4. Transducer Transmitting Response With and Without Lag Line

The left-hand side of the upper curve of Figure 4 shows what at first appeared to be the residual of a standing wave system influencing the receiving sound standard. An investigation of these undulations showed that interference from the sound returned from the face of the opposite instrument was causing variations in the motional impedance of the projector. This variation occurred in this disturbing degree over a frequency range of only a few kilocycles on either side of mechanical resonance of the transmitter, and could be eliminated by driving the instrument with a high impedance source.

The test distance was approximately 72 cm, which is the maximal distance obtainable in the small test vessel which contains a large volume of sound-absorbing lining.

IV. CONCLUSION

Further experimentation with transducers of this type is under consideration. The improved stability of other types of crystals would be preferable to the Rochelle salt crystals which were used. Magnetostrictive elements could be used, but are not being considered because of the extended frequency range desired.

Improved operation should also result from mechanical isolation of the separate rectangular crystal arrays which are now mounted on a common backing plate.

All measurements have proved this transducer to be a highly desirable projector, particularly in small tanks where testing distance is limited and c-w operation is used.